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JSC-11464

TECHNICAL MEMORANDUM

FIRST CONCEPT FOR A TROPICAL AREA MONITORING PROJECT

Prepared By

Health Applications Group
Life Sciences Directorate

National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

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TECHNICAL REPORT INDEX/ABSTRACT

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13. ABSTRACT

For purpose of discussion, a first concept of a tropical area monitoring project is presented. The project would develop an operational system capable of monitoring land areas by machine processing of satellite data. Landsat images would be processed within a controlled "Isolable Unit" to detect changes in forest cover, rangeland, soil integrity, and other factors important to conservation of tropical ecology. Because of the lack of current studies, an introductory developmental effort is needed to demonstrate the use of Landsat data in this application. The novel "Isolable Unit," which functions as a user organization within the developmental project, assures that the technology will be transferable to a user organization.

14. SUBJECT TERMS

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APPROVED BY

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ACRONYMS

IAA	International Aerospace Abstracts
ITOS/NOAA	Improved TIROS Operational Satellite/National Oceanic and Atmospheric Administration
NASA	National Aeronautics and Space Administration
STAR	Scientific and Technical Aerospace Reviews
UNEP	United Nations Environmental Program
SMS/GOES	Synchronous Meteorological Satellite/Geostationary Orbiting Earth Satellites

1. SUMMARY

This document concerns a worldwide monitor of tropical regions. It is presented only as a first concept, designed to stimulate discussion among the many persons interested in conservation of the ecology of tropical regions. It should satisfy the expressed need of the United Nations Environmental Program (UNEP) for an applied research program concerning the monitor of tropical areas.

It is written to fit the support contractor environment at the Johnson Space Center at Houston, where the originating office is located. Nevertheless, it can be easily adapted to any NASA facility, or with more changes, to a university or industrial environment. In short, it is set forth as a specific project only for the convenience of its public, since it is easier to comprehend explicit proposals than vague or exclusively conceptual ones.

The first phase, to take four years, would involve the testing of remote sensing technology on tropical areas, a capability which has not yet been adequately documented. The second phase, two years in duration, to start two years after the start of the first phase, would develop the procedures and the actual system. The third, or demonstration phase, would serve to train UNEP personnel.

A unique feature is the "Isolable Unit" concept which focuses on independence of the system from National Aeronautics and Space Administration (NASA) facilities in order to facilitate cost analysis and the transfer of technology. The primary focus of monitoring efforts will be on integrity of tropical forests, rangelands, and soils. The system as proposed would monitor one-eighth of the tropical land mass per year including one-fourth of its forest and brush.

2. GENERAL CONSIDERATION

2.1 BACKGROUND

For several years the United Nations has planned to monitor all the tropical regions of the world. Its environmental organization, UNEP, has made firm plans only for the use of photointerpretation techniques on Landsat images (refs. 1 and 2).

UNEP has not yet scheduled machine processing of Landsat data for two reasons. Foremost is the suspicion that the cost is exorbitant, both in equipment and personnel. It must also be admitted that remote sensing technology has not yet been demonstrated in this application.

To date, the analysis of remotely sensed data on tropical forests has been largely bypassed. No references in STAR (Scientific and Technical Aerospace Reviews) and IAA (International Aerospace Abstracts) show the use of Landsat data for tropical forests. Indeed, STAR only lists four references on remotely sensed data for these forests (refs. 3-6), and IAA lists only one (ref. 7).

Despite these facts, machine processing of information from earth observations satellites is the only cost-effective way to monitor the entire tropical area. This project will develop a relatively inexpensive system to serve the needs of UNEP.

2.2 PRIMARY MOTIVES

The two primary motives of the project are:

1. To demonstrate that present remote sensing technology is adequate for monitoring changes in tropical regions using Landsat imagery.
2. To develop a system for monitoring the tropical areas of the world in a cost-effective way using machine processing of Landsat data.

2.3 PHASING

There will be three distinct phases to this project as follows:

- Developmental Phase - in which the feasibility of classifying tropical areas is demonstrated in several ways, and certain areas of technology are extended.
- Trial Operational Phase - in which an operational system for performing the monitoring is developed.
- Demonstration or Training Phase - in which the monitoring effort is performed, isolated from all normal NASA services, in a true operational mode; at the option of UNEP, this can be used for training.

In general, NASA earth observations projects are considered to pass through four stages: research; exploratory studies; ASVT (Applied System Verification Test), and applications or operational use. In this case, existing general research suggests the feasibility of this project in such a way that the first stage can be considered completed. The developmental phase of this project corresponds to the exploratory studies. The trial operational phase would constitute the ASVT. Finally, the demonstration or training phase would be considered the applications, or operational, use of the system.

2.4 SPECIAL CONSTRAINT: THE ISOLABLE UNIT

UNEP requires that the system be low in cost and capable of being implemented independent of NASA. The UNEP budget is modest, and UNEP headquarters are located in Nairobi, Kenya; the monitor could be implemented there or in another tropical devloping country. The many resources of a NASA facility are largely missing in areas such as these.

So that there can be no confusion on costs or on transferability, an "isolable unit" will be a unique feature of this project.

This will be a completely independent unit which operates through well-defined, easily monitored interfaces with the rest of the world. It will be staffed with a limited contingent of people who play the roles of the UNEP staff. Special support for the unit will exist during the trial operational phase; it will nearly disappear by the end of the demonstration phase. Due to its isolability, determining the costs of equipment and operation will be relatively simple.

3. DEVELOPMENTAL PHASE

3.1 INTRODUCTION

There are few substantive references to the monitoring of tropical forests in STAR, IAA, and other references accessible through NASA's RECON system (refs. 3-7), and no such references on rangeland and soils. There is no body of scientific work openly published to show the feasibility of present technology for tropical monitoring; most references concern temperature regions.

The developmental phase will be used to demonstrate the capabilities of the technology now in existence, as applied to the tropics. Landsat imagery will be used to discriminate the major categories of important surface features in the tropics, using techniques developed for temperate regions. Where necessary, procedures and techniques will be developed to monitor categories unique to tropical areas.

3.2 TECHNICAL OBJECTIVES

There are a number of major categories that need to be monitored by the system. Listed in order of importance to this project, they are:

- Forests and brush
- Ranges and grasslands
- Areas of significant soil erosion
- Areas of human aggregation (cities, towns, etc.)
- Cultivated areas
- Other areas

To a certain extent, the motives of UNEP will be best served by more detailed classification of these features, especially

of the forest and wooded areas. In particular, changes in land use need to be monitored. To monitor these classes, some techniques in pass-to-pass registration need to be developed or, at least, implemented. Application of temporal classifications will need to be tested.

Certain practical problems must also be addressed. Among these are the availability of cloud-free Landsat images for the appropriate season of the year, the time scale of the changes being monitored, and others. This kind of information is needed to design the operational system.

There is a good possibility that certain meteorological satellites can furnish useful synoptic information about the earth's surface, even though they were designed for cloud studies. In particular, data from the SMS/GOES (Synchronous Meteorological Satellite/Geostationary Orbiting Earth Satellites), ITOS/NOAA (Improved TIROS Operational Satellite/National Oceanic and Atmospheric Administration) and Seasat satellites need to be studied.

3.3 FORESTS

The most pressing requirement involves the recognition of tropical forests and brush, and the monitoring of changes within them. The properties of the tropical rain forests, in particular, are different from temperate forests, so that procedures developed in temperate regions may not be very useful; they are diverse instead of homogeneous, and transitions within the forests are often gradual instead of abrupt.

A primary task in the developmental phase is to demonstrate the ways of recognizing and classifying the various types of forest and woodland. The limits of classifying these types from Landsat need to be determined. In particular, the precision and practicality of monitoring changes needs to be determined.

3.4 RANGELANDS

Present technology is probably transferable from temperate to tropical rangeland and grasslands, but this needs to be verified and demonstrated.

3.5 EROSION

There are no references in STAR and IAA concerning useful studies of soil erosion using Landsat data. Nevertheless, some studies are certainly feasible. For example, Landsat image 2224-15310-5 demonstrates the gross erosion problems around Ducktown, Tennessee, resulting from sulfur trioxide fumes of a primitive copper smelter. An effort must be made to demonstrate the scale of erosion that can be detected with machine processing of Landsat imagery of the tropics.

3.6 OTHER AREAS

For purposes of this project, detection of other areas will be mostly useful in conjunction with the above classes. For example, if forest areas are destroyed as a result of urbanization, then this needs to be recognizable from the classification efforts.

3.7 SUMMARY OF TECHNICAL OBJECTIVES

In summary, the following need to be demonstrated in the developmental phase:

- Recognition of tropical forests, brush, and rangelands
- Recognition of destruction or change of existing forests and brush
- Classification of tropical forests, as possible
- Demonstration of the potential of Landsat imagery for monitoring erosion

- Investigation of the potential of meteorological satellites as a source of synoptic information
- Determination of the availability of cloud-free Landsat images of the tropics.

3.8 PERSONNEL

The developmental effort could be carried out at several different levels, but a modest one would probably be adequate. As few as three professionals with remote sensing and botanical or ecological expertise could make great gains in two years, if well supported in facilities and given some flexibility in travel to tropical regions. Probably two years of such services would provide an adequate background of information to underlie the development phase, but two more years, concurrently with the development of an operational system, would be desirable.

3.9 DOCUMENTATION

A structured series of reports will be issued to interpret and document the conclusions reached in this phase. A final report will be compiled on the basis of the intermediate reports, and publication of the results in technical literature will be encouraged.

4. TRIAL OPERATIONAL PHASE

4.1 INTRODUCTION

In this phase, a rigidly isolable system will be developed for monitoring. The system will be supported in such a way that all services needed for development and operation of the system are separately identified from other NASA facilities. At the end of the project, the precise monitoring system that will be offered for use by UNEP should be identifiable as a very distinct unit.

4.2 ORGANIZATION

The heart of this effort will be the development of an isolable contingent of as few as five persons who play the roles of the permanent monitors and their staff. These might consist of a chief monitor; a professional monitor that can substitute for him; a clerical employee; and two computer technicians. The persons in these positions will be full time, assigned only to these roles, so that there can be no confusion about their isolability in the final system.

For developing the system, a contingent of project management and support people will be needed. The precise number is difficult to estimate at this stage, but the personnel required of a contractor effort (in addition to NASA management) would be the following:

- Project Manager
- Secretary
- (Deputy)
- Two professionals, one each in remote sensing and botany or ecology (probably the same two persons from the developmental phase)

- Support in:

  Computation and programming
  Scheduling and procedures
  Travel
  Documentation

The total effort could be as small as about fifteen man-year equivalents (not including the isolable unit) for the first year of the trial-operational phase, probably diminishing to about a third of its original size by the end of the second year.

4.3 BASIC ASSUMPTIONS

Monitoring an eighth of the entire tropical land mass would require the processing of 250 Landsat scenes, covering about one quarter of the forest land, broadly defined. This implies the processing of 500 taped images, since each current scene must be compared with a historical scene from archive.

On the average, registration, processing, and interpretation should take about two man days per scene if the motives are well defined and the procedures are well researched. This would involve the processing of two scenes on tape, one from archive, and one current tape. Most scenes would require much less work, but a few would require much more.

4.4 LOGISTICS

Logistics would be maintained relatively simply. Each scene can now be received and archived on a single tape. Certain data products, such as false color images, would be made and filed routinely. After processing, except in special cases, the tapes would be erased and recycled. Thus, the tapes would only be archived at Goddard, but images and reports of interpretation would be filed with the isolable unit. Reports could be converted to microfiche after formal issuance, so that full records would be preserved only in this way. In short, the permanent record on

each of the 250 scenes would not exceed about 1/4-inch of filing space and a microfiche card.

Nevertheless, during this phase, tapes might well be maintained for six-month periods to allow reworking of selected data. At the end of this phase, all such tapes would be recycled.

It is feasible to archive the base scene for each area in the tropics. If the UNEP prefers that the organization become an archive for a data base for tropical regions, it might be reasonable to include such a library of 2000 tapes within the isolable unit. However, this concept should be discouraged since it is probably not cost effective.

4.5 COMMENTS ON THE ISOLABLE UNIT

The concept of an isolable unit is new to NASA projects of this sort. Nevertheless, it seems to be the best way to overcome problems of technology transfer that plague NASA projects. The unit contains role-playing persons, its own non-shared equipment, defined interfaces with other persons, and well-defined interface with external equipment and facilities. If feasible, it should also have a unique, physically isolated room for housing the unit. Special care needs to be taken to ensure that it is a unit that can be transferred to a user organization without the appearance of unknown problems or costs.

The persons included in the unit will be required to perform their functions relatively isolated from others at NASA, at least in a psychological sense. They must play the roles of the monitoring personnel of the finished system. The isolability of their functions is especially important since the unit might well be located at UNEP Headquarters in Nairobi, Kenya, far removed from convenient access to NASA's resources.

Isolability of equipment is also vital, and perhaps more

difficult to implement. Probably the project should be developed around a system such as the General Electric Image-100, augmented by clustering and parametric classification programs. If separate facilities are not available, isolability could be implemented by software prohibitions to the use of equipment that would not be available to the system to be transferred. If desired, UNEP could purchase equipment to be used by NASA and later transferred to Nairobi or any other area.

4.6 AIRCRAFT STUDIES

It is probably well to avoid the collection of aircraft imagery by NASA in support of this project. In general, NASA prefers to avoid remote sensing aircraft missions outside of the territorial United States.

Certain imagery of tropical areas, now in existence for Puerto Rico, Brazil, and some other areas, might prove useful. In addition, where a tropical country has access to instrumented aircraft, it may be feasible to arrange cooperate remote sensing missions.

4.7 DOCUMENTATION

There is a strong need for exhaustive documentation is this phase to ensure that the technology can be transferred easily. Documents will be prepared at various levels, starting at overviews of the entire system and its capabilities, and proceeding to individual procedure manuals.

Particular effort is needed to ensure that documents are written in a clear way, avoiding the space jargon that appears in many aerospace documents. They all should be directed to the average scientist; they must be comprehensible, for example, to a foreign-educated botanist whose native language is not English.

Due to the isolability of the unit, preparing manuals for the equipment to be used will be relatively straightforward. More difficult will be the technical manuals on classification of areas. Nevertheless, the isolability criterion will simplify this task also. Final documentation will include the following as a minimum:

- Overview of the system
- Detailed review of physical components of the system, including the space occupied and utilities needed
- Review of personnel needed to operate the system, including requirements in education and experience
- Manual for basic operation of each item of equipment
- Complete manual of logistics (supplies, images, etc.)
- Test on the purposes and general procedures of the monitoring system
- Detailed procedures for monitoring an area using Landsat tapes
- Details on classification procedures
- Samples of the complete process of monitoring representative areas
- Exhaustive review of costs of operation of the system

All documents will be independently reviewed to assure their usefulness to UNEP personnel.

5. DEMONSTRATION OR TRAINING PHASE

5.1 PURPOSE

This phase will assure the orderly transfer of this technology to the user, UNEP. It will demonstrate the system for one year of operation at a NASA facility, or by prior arrangement, at any location designated by UNEP. The criterion of isolability in the second phase will assure that a minimum of problems occur during this transfer.

5.2 PROCEDURES

At this point, the technology will be in a stand-alone position, and the documentation will be complete. It only remains to demonstrate the isolable unit in isolation at a NASA facility, or to demonstrate the use of UNEP's equipment in the UNEP facility.

The actual procedures depend on the participation of UNEP in the previous phases. If there has been an observer at NASA through the entire effort, the observer would probably be sophisticated enough to begin work as monitor with little or no assistance. At the other extreme, if no UNEP personnel have participated, they could be shown the operation, or they could be given on-the-job training.

6. COORDINATION WITH UNEP

The UNEP program for environmental monitoring consists of separate portions, some of which are now being addressed, and some of which are still being discussed. One that has been proposed but not yet implemented is an "applied research program... to adapt these techniques ["of automated interpretation"] to the needs of the monitoring of the tropical forest cover." (ref. 2, p. 21)

This project would satisfy this portion of UNEP's requirements. It would also provide information on monitoring rangelands and possibly on monitoring soil integrity, all of which are requirements for other programs within UNEP.

From its previous actions, it is apparent that UNEP will require that any system be made operational within a developing country in the tropics. A prime possibility would be Nairobi, Kenya, where their headquarters are located, but many other tropical countries are also likely candidates. The "Isolable Unit" concept built into this project will assure that this will be feasible.

It is especially desirable that UNEP personnel participate in the second phase of this project. Preferably, the persons who would actually be the monitors could work in the developmental tasks, or even develop their role as part of the isolable unit. If well qualified in botany or ecology, they might also participate in the first phase. Participation of UNEP personnel is absolutely necessary in the third phase, since meaningful technology transfer cannot occur without them. If possible, the full operational staff of UNEP should participate in on-the-job training.

It should be noted that UNEP now has in operation a pilot project on photointerpretation of Landsat images of tropical forests in Africa. This project will certainly yield much information of benefit. A sound liaison must be maintained with UNEP to assure that all such information will play an effective role in the development of this project. The photo-interpretation project of UNEP might well be combined with the project proposed here, or the same personnel used in both projects. This would be an important point of discussion with UNEP officials.

7. SCHEDULES AND RESOURCES

The following is an ideal distribution of tasks:

- Phase 1: Developmental Phase - Start immediately; continue two years; tasks may continue in second phase
- Phase 2: Trial Operation Phase - Start within two years; continue two years
- Phase 3: Demonstration and Training Phase - Start at end of second phase and continue for one year.

A possible distribution of staff and support is given in figure 1. As can be seen, the peak period would occur at the beginning of the Trial-Operational Phase.

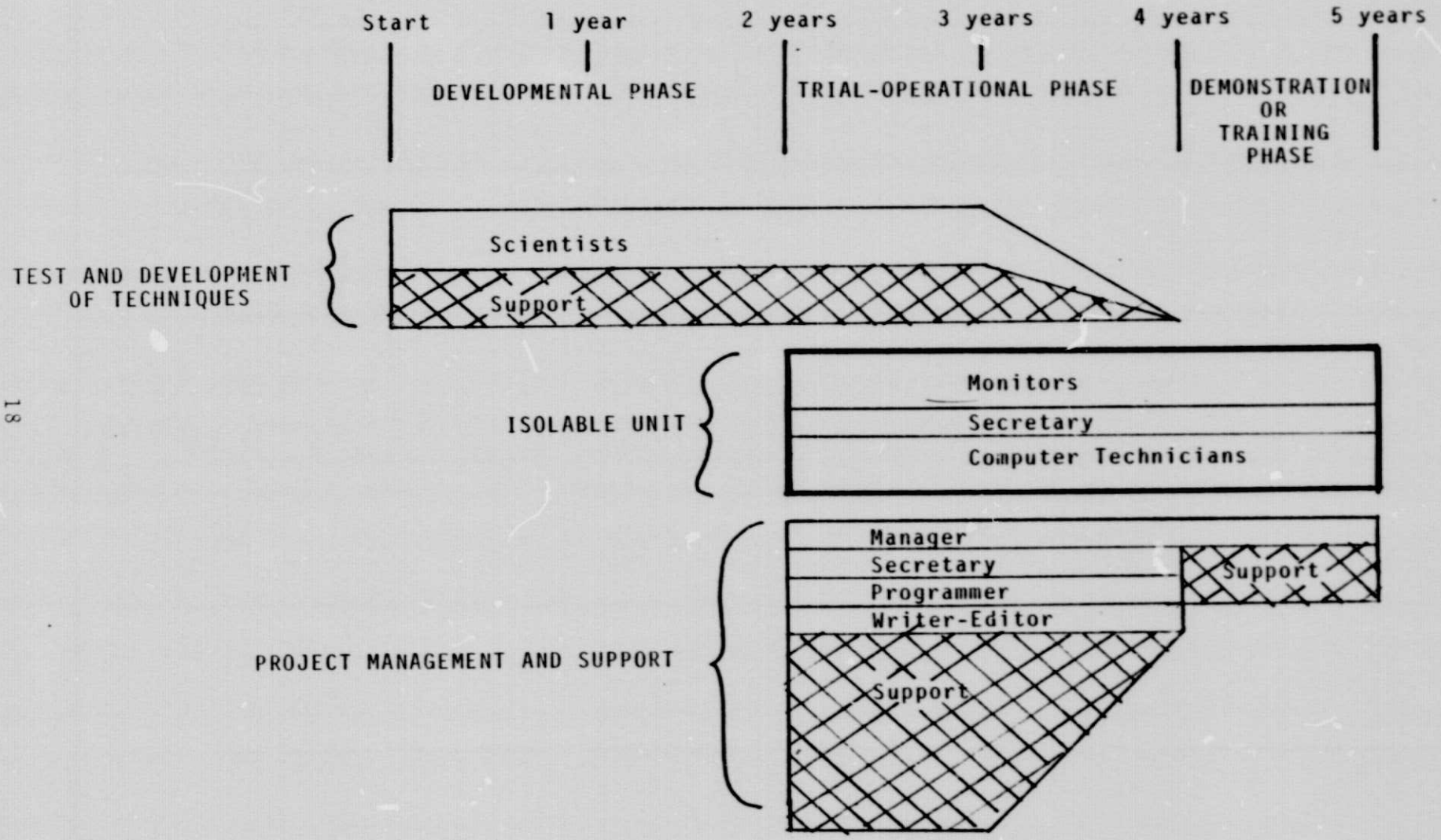

Figure 1. – Suggested staff and support.

8. REFERENCES

1. Brian Martin and Francesco Sella, "Earthwatching on a Macroscale", Environmental Science and Technology, volume 10, 230-233 (March 1976) both authors are affiliated with the United Nations Environmental Program.

2. UNEP, FAO: Formulation of a Tropical Forest Cover Monitoring Project. Rome (1975): This is an excellent source of technical information on the UN's concept of this project, with a valuable list of references.

3. Leschack, L.A.; Brinley, W.R., Jr.; and McIvor, D.E.; Automatic Processing of Airborne Remote Sensing Data for Pattern Discrimination of Jungle and Other Vegetation Areas. Development and Resources Transportation Co., Silver Springs, MD, May, 1973, (73N29410#).

4. Adams, J.B.: Larsen, J.D.; and Bond, R.M.: Incident and Reflected Solar Radiation in a Tropical Environment. Caribbean Research Institute, St. Thomas, Virgin Islands, February 1, 1972, (73N10417#).

5. Environmental Data Base for Regional Studies in the Humid Tropics. Army Tropic Test Center, Fort Clayton, Canal Zone, May, 1968. (68N38177#).

6. Mower, Roland D.: An Analysis of Multispectral Imagery for Tropical Land Use Discrimination. AGARD Propagation Limitations in Remote Sensing, October, 1971 (72N16111#).

7. Versteegh, P.J.D.: Assessment of Volume Characteristics of Tropical Rain Forests on Large Scale Aerial Photographs. ITC Journal, P. 330-341, 1974, (75A38888).